MFJ

HF/VHF SWR Analyzer

Model MFJ-259C

INSTRUCTION MANUAL

CAUTION: Read All Instructions Before Operating Equipment

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VERSION C1

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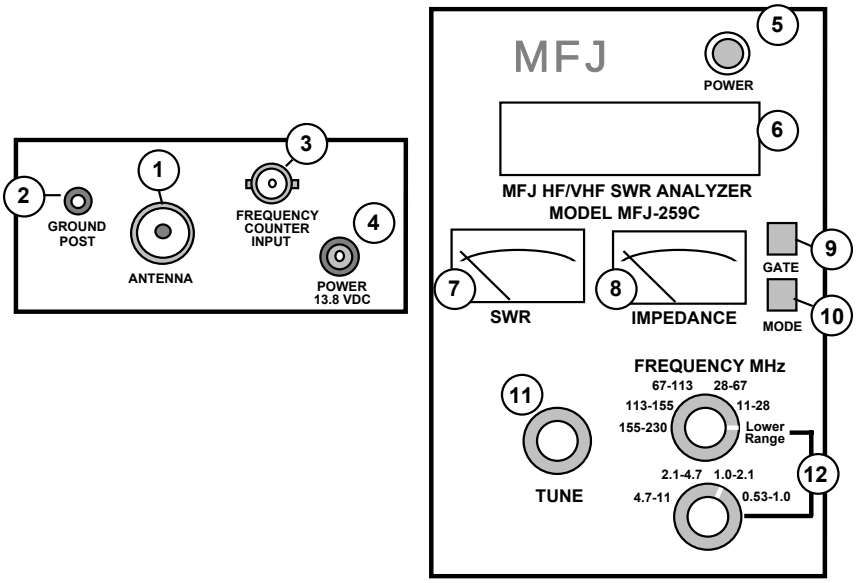
1.0 Introduction

The MFJ-259C is a compact battery-powered RF-impedance analyzer that covers 0.53-230 MHz in nine overlapping bands. Fully portable and self contained, it delivers a wide range of basic and advanced RF measurements to present a complete picture of your antenna systems and networks. It also measures capacitance, inductance, and serves as a discrete signal generator and frequency counter for the test bench. The MFJ-259C is the latest entry in a long line of time-tested designs using proven technology and rugged construction to ensure years of reliable service. Please read through this manual carefully before powering up your analyzer for the first time. The manual contains *important safety information* you'll need to know to avoid damaging your unit. There's also valuable operating instruction to help you to take advantage of its full range of functions and features right away.

1.1 MFJ-259C Control Layout

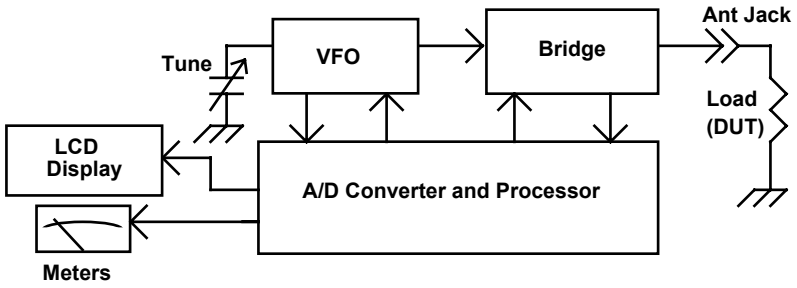


1. Antenna Port: SO-239 for attaching antennas and RF devices under test.
2. Ground Post: Binding post for attaching leads to chassis ground.
3. Counter Input: BNC-female input jack for analyzer's *Frequency Counter* function.
4. External Power: 2.1-mm power jack accepts power adapter or supply (13.8V + center pin).
5. Power Switch: Applies power from internal batteries or external power source.
6. LCD Display: Two-line digital display presents operating frequency and measured data.
7. SWR Meter: Provides continuous analog readout of SWR measurements (Zo=50).
8. Impedance Meter: Displays impedance magnitude or reactance measurements.
9. Gate: Push button sets counter gate speed, performs other specified functions.
10. Mode: Push button selects measurement mode, performs other specified functions.
11. Tune: VFO capacitor, provides analog frequency control for the analyzer's generator.
12. Frequency: High and low-range band switches select analyzer's operating range.

1.2 Analyzer Measurement Functions

- **SWR:** LCD display and analog meter, Zo = 50Ω or Zo programmable
- **Complex Impedance:** Resistive and Reactive components (R ±jX)
- **Vector Impedance:** Z-magnitude plus Phase Angle
- **Impedance (Z):** Analog meter display, Zo=50 Ω
- **Return Loss:** Digital display, in dB
- **Inductance (uH), Reactance (X_L):** Digital display with frequency
- **Capacitance (pF), Reactance (Xc):** Digital display with frequency
- **Resonance:** Digital and analog reactance null (X=0) with frequency
- **Electrical Length:** Digital, measured in feet.
- **Feedline Loss:** Digital, measured in dB
- **Signal Frequency:** Discrete counter function with three gate speeds
- **Signal Generation:** 20-mW (3-Vpp) output into 50 Ω, > -25 dBc suppression.

1.3 Theory of Operation: The MFJ-259C has four basic electronic elements. (1.) A tunable *VFO* with counter readout that generates RF signals to energize the load or device under test (DUT). (2.) A *Directional Coupler* (or bridge) to measure RF incident and reflected voltages sent to the load. (3.) A *Central Processor* that reads bridge voltages and processes them into usable data. (4.) A *LCD Display* and two analog meters that present all computed data visually. The processor also performs other mathematical calculations and conversions.



The MFJ-259C will serve as your eyes and ears when working with RF systems. However, all handheld analyzers share certain limitations, and being aware of them will help you to achieve more meaningful results.

1.4 Local Interference: Like most hand-held designs, the MFJ-259C uses a broadband directional coupler that is open to incoming signals across the radio spectrum. Most of the time, the unit's built in +5-dBm RF generator is powerful enough to override any interference caused by stray pickup. However, under some circumstances, a powerful nearby transmitter could inject enough RF energy through the antenna being tested to overload the coupler and disrupt readings. If overload occurs, measurements may become erratic or SWR readings inaccurately high. These occurrences are rare, but if it becomes a problem at your particular testing location, the ***MFJ-731*** *Tunable Analyzer Filter* is especially designed to notch out unwanted signals with minimal impact on analyzer accuracy.

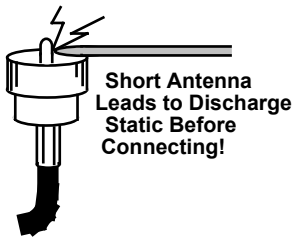
1.5 Calibration Plane: Your analyzer's *Calibration Plane* is the point of reference where all measurements have greatest accuracy *(Gain Reference = 0dB* and *Phase Shift = 0 degrees)*. For basic handheld units like the MFJ-259C, the calibration plane is always *fixed at the analyzer's RF connector*. Any time a transmission line is installed between the analyzer's RF connector and an item being tested, the cable will displace the load from the calibration plane and introduce some form of measurement transformation.

For SWR measurement, installing lengths of feedline usually causes a slight reduction in readings caused by attenuation losses. Unless the cable losses are high, the difference is usually insignificant. However, when documenting the performance of a new antenna design or network device, the analyzer should always be connected as close to the load as possible to minimize padding down of SWR readings.

Displacement of the calibration plane becomes far more significant when measuring impedance because of phase rotation and transformer action occurring in the feedline. In fact, impedance readings may swing dramatically, depending on the cable's electrical length and the severity of the load's mismatch referenced to 50 Ohms. To collect meaningful impedance data for a device, *always connect the analyzer directly -- using the shortest cable possible.*

1.6 Reactance Sign Ambiguity: Most handheld analyzers, including the MFJ-259C, lack the data processing capability required to calculate *Reactance Sign.* These signs are (**+)** for inductive reactance $\mathbf{X_L}$ and (**-**) for capacitive reactance **Xc**. In most cases, you can apply one or more simple tests to determine sign. See specific measurement instructions for details.

1.7 Protecting Your Analyzer: To minimize measurement error at high frequencies, the analyzer's detector diodes are installed directly at the antenna port. Be aware that applying *any external potential* exceeding a few volts of RF, AC, DC, or ESD energy could cause damage. Caution and common sense are the best protections against failure. Never connect a transmitter to the **Antenna** jack, and when testing ungrounded antenna systems that could accumulate a static charge, always short the connector before attaching it to the analyzer.



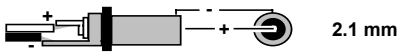
Important Warning: Never applying an external voltage to the Antenna jack -- it could damage sensitive detector diodes. Also, always discharge the coax connector to bleed off static before attaching ungrounded arrays.

2.0 Power Management

Read this section carefully -- *supplying the wrong external voltage or failing to follow battery installation procedures could result in permanent damage!*

2.1 External Power Requirements: The MFJ-1312D AC adapter meets all technical requirements for powering the analyzer and it is recommended. Any other external power source must meet the following specifications:

- **Current:** 250 mA or greater
- **Voltage Range:** 11-16 VDC, well filtered (14 VDC ideal)
- **Battery Charging:** 13.8 VDC *minimum required for battery charger operation*
- **Polarity:** Negative ground only
- **Connection:** 2.1-mm (**+**) center pin, (**-**) chassis ground (see below)

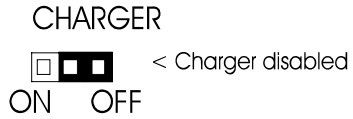


2.2 Internal Battery Power: Always install fresh cells with identical part numbers and expiration dates. For non-rechargeable power, install premium Alkaline cells and remove weak cells *immediately* to prevent leakage. For rechargeable power, NiCds work well but Ni-MH cells have no charge memory, hold a charge longer, and offer greater storage capacity. Before loading new cells, always check (or know) the *charger operating status* -- is it **On** or **Off** ?

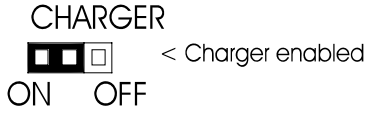
Important Warning: You must disable the analyzer's charger circuit when using non-rechargeable batteries, or destructive cell damage and chemical leakage may result.

2.3 Setting The Charger: Remove the analyzer's back cover (4 screws on each side of the case). Find the upper left-hand corner of the main pc board and locate the 3-pin header **J5** next to the power jack. A small black shorting plug is installed on the header.

Charger *Off* (non-rechargeable cells), install header on center and right pins as shown:



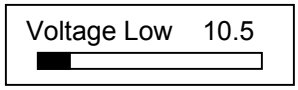
Charger *On* (rechargeable cells), install header on center and left pins as shown:



The charger provides a near-constant 20-mA/hr "trickle" rate any time external power is applied. The **Power** switch need not be on for charging to take place. Charging depleted cells may require 12 hours or more, so always allow enough time. Batteries will not over-charge.

Important Warning: Never store your unit more than a month with batteries installed. Also, never ship with batteries installed or swap cells with the power switch "On"!

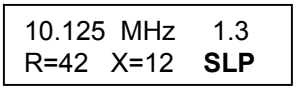
2.4 Low Voltage Alert: If the batteries (or external DC supply) drops below 11 Volts, a flashing warning will appear on-screen (see below):



Tapping the **Mode** button *one time* disables the warning and allows you to continue testing, *but measurements made at low voltage may not be reliable.* If possible, plug in an external power source or discontinue testing until batteries are replaced or recharged.

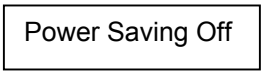
2.5 Sleep Mode (Standby): The MFJ-259C normally draws around 220 mA, consumed mostly by the stimulus generator's amplifier stages. To extend battery life, your unit features a built-in standby function called **Sleep Mode**. Sleep Mode shuts down signal generation and reduces current drain to under 15 mA during periods of analyzer inactivity.

The analyzer's processor monitors activity by sensing activation of the **Mode** switch and by looking for any change in the **Tune** control greater than 50 kHz. If neither event occurs during a *three-minute interval*, the processor registers "inactivity" and switches into standby or *Sleep* mode. A blinking **SLP** message on the display signals shutdown (see below):



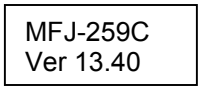
2.6 Wake Up (Cancel SLP): To pull the unit out of **SLP** (standby), momentarily press either the **Mode** or **Gate** button and resume normal operation.

2.6 Disable SLP: You may disable the **SLP** function manually if it interrupts your work. To disable it, turn the analyzer **Off,** then turn it **On** again while holding down the **Mode** button. Continue holding **Mode** until the copyright message appears on the screen, then release it. When **SLP** is defeated, the message shown below will appear:

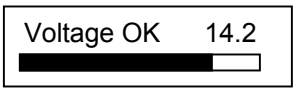


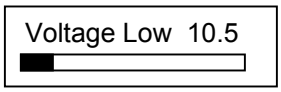
Note that **SLP** is a *default function* in the MFJ-259C -- it resets automatically each time you power up *unless you hold down the **Mode** key to defeat it.* To restore the **SLP** function at any time during an ongoing test session, simply turn the analyzer **Off** and then reboot it **On** again.

2.7 Powering-up (Boot) Sequence: To turn the analyzer **On,** press **Power**. Three boot screens appear in sequence before the analyzer enters it's default *SWR* **R&X** measurement mode. The first two screens show the analyzer's software version and copyright date (important information when seeking technical assistance from MFJ):

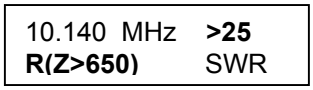


The third screen provides a voltage check -- and flashes a warning if voltage is too low:





The fourth screen shows the operating frequency plus **SWR** and **R&X** impedance data. This is the analyzer's *default measurement mode*. With no load connected to the **Antenna** jack, *SWR* and *Impedance* (Z) will be very high, falling well outside the analyzer's normal measurement range (greater than 25:1 and 650 Ohms):

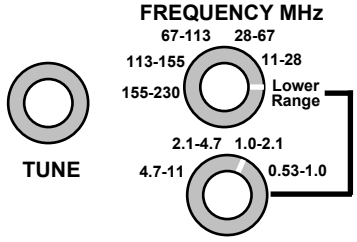


See *Chapter-4.2* for complete measurement-mode R&X operating instructions.

3.0 VFO Frequency Control

The MFJ-259C's expanded-coverage VFO spans the LF, HF, and VHF spectrum from 0.53 MHz (AM broadcast) to 230 MHz (135-cm) in nine bands.

3.1 Band Switching and Tuning: Two **Frequency MHz** switches select high and low bands. The *High-Frequency* band switch must be set fully clockwise to enable the *Low-Frequency* band switch (see below).



The VFO **Tune** capacitor features a reduction driver to provide smooth continuous frequency control with a small amount of overlap at each band edge.

3.2 LF (630 Meter) Modification: You may shift LF-VFO coverage down to the experimental 630-Meter band (472-479 kHz). First rotate **Tune** counter-clockwise to its stop (lowest frequency). Then, remove the back of the case (4 screws each side) and remove the battery tray (2 screws on right side). Find the access hole for the 0.53-1.0 MHz tuning slug at the very bottom-center of the pc board (only coil using a hex slug). Using a 2-mm insulated hex wand, adjust the inductor while watching the LCD frequency display for 0.47 Mhz. Coverage should now be ~0.47-0.94 MHz.

3.3 Signal Generator Function: You may use the output signal from the analyzer's internal VFO as a discrete signal source (or signal generator) for testing purposes. Connect via the SO-239 **Antenna** jack. Signal level is approximately 3-Vpp (20 mW into 50 Ohms or +5 dBm)

with all harmonics suppressed below -25 dBc. Although not phase-locked, stability is adequate for most general alignment applications. To protect the bridge diodes from accidental DC voltage applications, we strongly recommend installing an in-line attenuator or coupling capacitor to provide isolation.

4.0 Basic Measurement Modes

4.1 The Basic Operating Menu: The MFJ-259C *Basic Menu* presents the analyzer's most frequently used measurement functions. Tap the **Mode** switch to step through each one -- or hold it down to scroll through them at a 3-second-per-screen rate. Selections are:

1. R&X: Measures **SWR, R** (*Resistance*), **X** (*Reactance*)**, Z** (*Z-magnitude*), and □ (*Phase*)**.**
2. Coax Loss (dB): Measures loss at any given frequency for 50-Ohm coax or a DUT.
3. Capacitance (pF): Measures component's reactance, computes capacitance.
4. Inductance (uH): Measures component's reactance, computes inductance.
5. Frequency (MHz): Counter mode, measures frequency of an external RF source

Each menu selection opens with an *Identifier Screen*.* After a brief pause, a *Working Screen* appears to present data. The menu is circular, reverting back to the beginning.

*On analyzer boot-up, the **R&X** *Working Screen* appears without its identifier screen. However, the *Identifier Screen* will appear when stepping or scrolling through the menu:

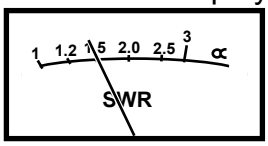
Impedance **R & X**

4.2 Measuring SWR, R, X, Z, and □: This default function measures and displays five of the most widely used network parameters simultaneously. To access and view measured data for **SWR**, **R, X, Z, and** □, follow the checklist below:

[ ] Turn on the analyzer and allow it to boot to the default mode (**R&X**).
[ ] Adjust the **Frequency** switches and **Tune** control to the desired test frequency (**MHz**).
[ ] Connect the feedine (or load) to the analyzer's **Antenna** jack.
[ ] Read numerical *Standing Wave Ratio* (**SWR**) in the upper right-hand corner of the display:

10.120 MHz		**1.5**
R= 73	X=5	SWR

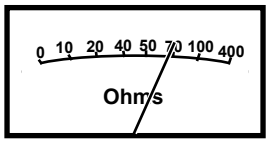
[ ] Also, read **SWR** on the analog panel meter display:



[ ] Read *Complex Impedance* (**R** and **X**) on the bottom line of the display:

```
10.120  MHz      1.5
R=  73           X=10
```

[ ] Read *Impedance Magnitude* (**Z**) on the analog meter scale.



[ ] Read *Impedance Magnitude* (**Z**) and *Phase Angle* (□) presented numerically by *pressing and holding the* **Gate** *button.* The LCD display changes, as shown below:

```
10.120  MHz     1.5
Z= 75   □= 5° SWR
```

[ ] Release **Gate** to revert back to **R&X**.

Note that *Reactance* readings (**X**) could be *inductive* (**+ X_L**) *or capacitive* (**- Xc**) because the processor can't calculate the sign. However, you can often find the sign by installing a small capacitor across the feedline connector to add a few ohms of capacitive reactance. If your capacitor increases **X**, the load is likely capacitive (**-**) because your reactance added to it. On the other hand, if your capacitor caused X to decrease, the load is likely inductive (**+**) because it cancelled out some of the **X**. To ensure accuracy, keep the amount of **Xc** you add as small as possible.

Also, when measuring through a feedline, always remember the values for **R, X, Z, and** □ are displaced values measured *at the analyzer's calibration plane* and *do not represent the actual impedance of the device connected at the far end.* To read the impedance of the device under test accurately, you must connect directly to the DUT using the shortest leads possible (or use an electrical half-wave of 50-Ohm cable) .

4.3 Measure Coax Loss (dB): This mode displays the *Measured Loss* in **dB** at the **VFO** operating frequency for any length of 50-Ohm coax cable. It will also measure losses incurred through 50-Ohm attenuators, transformers, or baluns. To measure *Loss*:

[ ] Turn on the analyzer and allow it to boot to the default mode (**R&X**).
[ ] Press **Mode** *once* to access **Coax Loss** and wait for the working screen.
[ ] Adjust the **Frequency** switches and **Tune** control to the desired test frequency (**MHz**).
[ ] Connect the feedine under test (or 50-Ohm device) to the **Antenna** jack.
[ ] *Make sure the far end of the coax or the output port of the device is unterminated*.
[ ] Read Coax Loss on the lower line of the LCD display:

```
10.120   MHz
Coax Loss =  2.1 dB
```

As you change VFO frequency, the display will track any change in loss in real time (losses normally increase with frequency). Remember, **Loss** mode is only accurate for 50-Ohm cable or 50-Ohm devices, and these must be unterminated at the far end.

4.4 Measure Capacitance (pF): This function measures the reactance of an unknown device in Ohms (**X**) at a given test frequency and computes the component's capacitance value in **pF**. To measure capacitance:

[ ] Turn on the analyzer and allow it to boot to default mode (**R&X**).
[ ] Press **Mode** *twice* to access **Capacitance** and wait for the working screen.

Capacitance in pF	**10.120 MHz C(Z)>650 Xc**

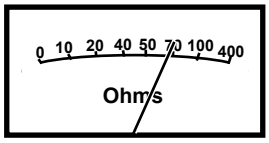
[ ] Adjust the **Frequency** switches and **Tune** control to the desired test frequency (**MHz**).
[ ] Using the shortest leads possible*, connect the capacitor to the **Antenna** jack.

*Alternatively, use the same lead length used in the actual circuit to incorporate stray lead inductance in your measurement.

[ ] Read *Reactance* (**Xc**) in Ohms on top line and *Capacitance* in **pF** on the lower line:

3.500 MHz **71**
C= **642 pF** Xc

[ ] Also, read Reactance (**Xc**) in Ohms on the analog *Impedance* meter:



The measurement range for *Reactance* is 7-650 Ohms. Outside that range, the analyzer will display one of the following error messages:

Too low to measure (X<7) Series-resonant (X=0) Too high to measure (Z>650):

3.500 MHz **C (X<7)** Xc	3.500 MHz **C (X=0)** Xc	3.500 MHz **C (Z>650)** Xc

Sign Ambiguity: In capacitance mode, the analyzer measures reactance (**X**) and the operating frequency, then mathematically converts it to capacitance (**pF**). However, the processor can't determine if the reactance sign is minus (-**Xc**). When in doubt, tune the VFO *up in frequency* and see if the value of **X** *decreases*. If it *decreases*, the device is likely

capacitive because the reactance exhibited by a capacitor tends to decrease as frequency increases.

Standard vs. Measured Values: Even though a *Standard Value* may be stamped on the case, a capacitor rarely measure that value at RF because of ambient temperature, manufacturing tolerances, and differences in the test frequency. The sensitivity to frequency occurs because stray inductance compounding inside the device and along the leads running to the analyzer's calibration plane form a series-LC circuit. Normally, this condition causes a capacitor's value (in pF) to *increase* with frequency, and it may even reach infinity if the circuit becomes *series-resonant* (X=0).

4.5 Measure Inductance (uH): This function measures the reactance of an unknown inductor in Ohms (**X**) at a given test frequency and computes inductance in **uH**. To measure inductance:

[ ] Turn on the analyzer and allow it to boot to default mode (**R&X**).
[ ] Press **Mode** *three times* to access **Inductance** and wait for the working screen.

Inductance in uH	**100.000 MHz L(Z)>650**

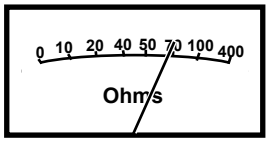
[ ] Adjust the **Frequency** switches and **Tune** control to the desired test frequency (**MHz**).
[ ] Using the shortest leads possible, connect the inductor to the **Antenna** jack.

Alternatively, you may use the same lead length used in the actual circuit so stray inductance will be incorporated into the measurement.

[ ] Read *Reactance* (**X_L**) in Ohms on top line, and read *Inductance* in **uH** on the lower line:

100.000 MHz
76

[ ] Also, read Reactance (**X_L**) in Ohms on the analog *Impedance* meter:



The measurement range for *Reactance* is 7-650 Ohms. Values falling outside that range will prompt one of the following error messages:

Too low to measure (X<7)	Parallel-resonant (X=0)	Too high to measure (Z>650)
100.000 MHz **L (X<7)** X_L	100.000 MHz **L (X=0)** X_L	100.000 MHz **L (Z>650)** X_L

Sign Ambiguity: In *Inductance* mode, the analyzer measures reactance (**X**) and the operating frequency, and then mathematically computes *Inductance* in **uH**. However, the processor can't determine if the reactance sign is positive (+$\mathbf{X_L}$). When in doubt, tune the VFO *up in frequency* and see if the value of **X** *increases*. If it does *increase*, the device is likely inductive because reactance exhibited by an inductor normally increases with frequency.

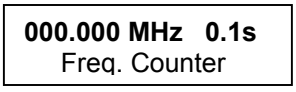
Standard vs Measured Value: The *Standard Value* for most inductors is determined at low frequency (often in the kHz region). At RF, the value in uH may measure substantially different because of stray capacitance between windings and other parasitic influences such as lead capacitance or even the coil's proximity to other objects. Typically, the value in uH will increase with frequency as the device moves closer to self-resonance. At self resonance, the inductor looks like an *open circuit* (or a trap), exhibiting infinitely high reactance. Conversely, at some very low frequency, it may look like a dead short.

4.6 Frequency Counter Mode: This function makes the analyzer's frequency readout circuitry available as a discrete frequency counter for your test bench. Like many counters, sensitivity for "locked-up" readings gradually decreases at higher frequencies. At HF, the measurement threshold is under 10 mV-pp, but gradually increases to nearly 200 mV-pp at 230 MHz. The "never-exceed" input voltage for safe testing is 2.0 V-pp.

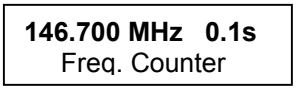
Important Warning: Never exceed 2-Volts peak-to-peak or apply a DC voltage to the Counter Input. Also, never connect a transmitter or unknown signal source to the input.

To access the counter function:

[ ] Turn on the analyzer and allow it to boot to default mode (**R&X**).
[ ] Press **Mode** *four times* to access **Freq. Counter** and wait for the working screen.

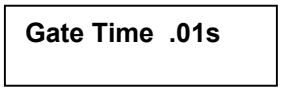


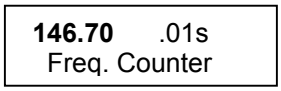
[ ] Connect your signal source to the BNC-Female **Frequency Counter Input** connector.
[ ] Read **Frequency** in MHz and **Gate** time in seconds (0.1s) on the top line of the display.



The default gate speed is **0.1** second, providing **1-kHz** resolution. Other options are **.01** second (very fast gate) with **10-kHz** resolution and **1.0** second (slow gate) with **100-Hz** resolution. To change the Gate speed:

[ ] Press **Gate** *once* for **.01-sec** gate time. Two screens appear in rapid succession:





[ ] Press **Gate** *again* for **1.0**-**sec** gate time:

Gate Time 1.0s

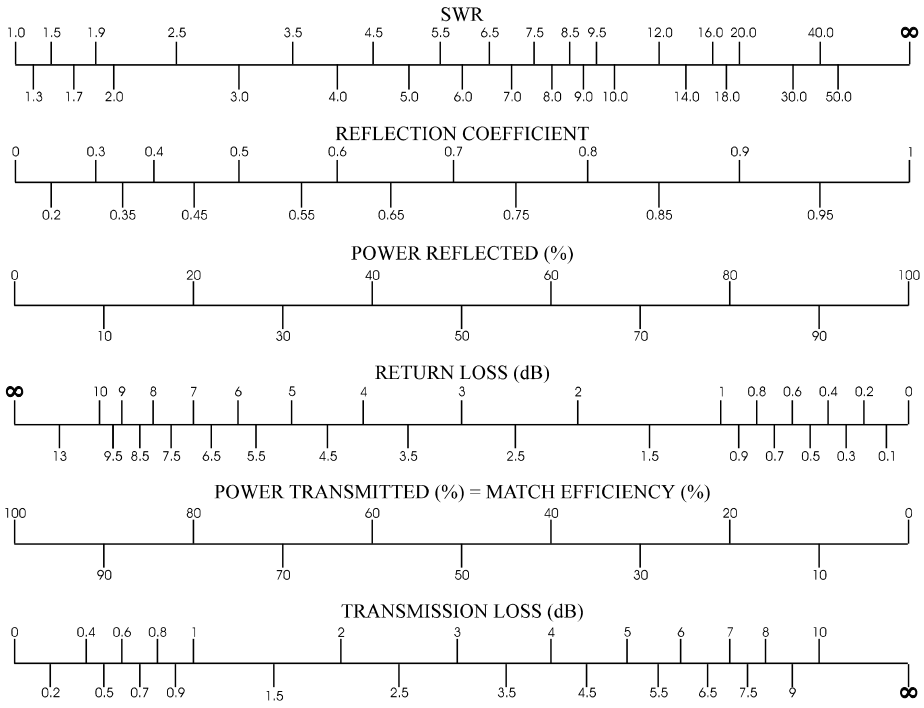
146.7000MHz 1.0s Freq. Counter

To return to the **0.1-sec** default speed, press **Gate** *again*. Note that response time to commands entered in the **1.0-sec** gate setting *is very slow*. It may take several seconds for the function to come up initially and several more seconds before it will respond to the command to return to default.

5.0 Advanced Measurements

5.1 Introduction: The *Advanced Menu* provide accurate *Distance to Fault* measurement for pinpointing transmission line problems in **Feet**. It also provides *Resonance* detection, useful for quickly identifying the exact frequencies where **X=0.** In addition, it measures *Impedance Magnitude* (**Z**,□) as the primary display function -- eliminating the requirement to press and hold down the *Gate switch* when making those measurements.

Finally, *Advanced* mode measures *Return Loss*, *Reflection Coefficient*, and *Match Efficiency,* all engineering parameters directly related to SWR. Note that, for general antenna work, *SWR* remains the most universally applied measure of array performance -- and it is really the only data needed to get most jobs done. Advanced terms address SWR from different technical perspectives and applying them correctly usually requires a deeper understanding of RF engineering principles. For reference purposes, the chart below illustrates how these and other advanced engineering concepts all equate directly to the basic SWR measurement:



As you enter *Advanced* mode, keep in mind that all of the same operating limitations and precautions that applied in *Basic Menu* also apply here.

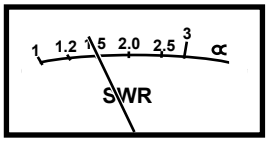
5.2 Enter Advanced Mode: The **Advanced Menu** works the same as the **Basic Menu,** with five functions arranged in sequence. To enter **Advanced Mode**, simultaneously *press and hold down* **Mode** and **Gate** together until the **Advanced** screen appears -- then release. Advanced Menu functions appear in the following order:

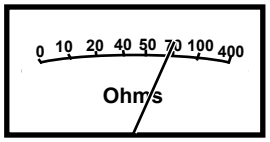
1. Impedance Magnitude (Z, □)
2. Return Loss (RL) and Reflection Coefficient (ρ)
3. Distance To Fault (DTF)
4. Resonance (X=0)
5. Match Efficiency (η)

5.3 Measure Impedance Magnitude: Releasing **Mode** and **Gate** bypasses the *Impedance Magnitude identifier screen* and displays the working screen by default (same as *SWR R&X* in the Basic Menu). If the **Antenna** jack is open, the display will show a high-impedance "out-of-range" message. If a measurable load is connected to the **Antenna** jack, the normal **Z-Mag** data screen appears (see below):

Advanced Identifier	Z-Mag default, no load	Z-Mag default, measurable load
Advanced	10.140 MHz **>25** **R(Z>650)** SWR	10.120 MHz 1.5 **Z= 75 □= 5° SWR**

The maximum impedance limit is set at 650 Ohms, as indicated by the error message. The analog meters also function in this mode, showing both **SWR** and **Impedance** Magnitude:





To access the other *Advanced* menu selections, simply *step* or *scroll* past the ***Z-Mag*** function using the **Mode** switch. On subsequent rotations through the menu, the *Impedance Magnitude* introductory screen will appear in sequence with the others:

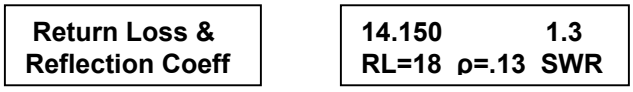
Impedance **Z = Mag, □ = Phase**

5.4 Return Loss and Reflection Coefficient: *Return Loss* (**RL**) measures how many dB down the *reflected wave* is when referenced to the forward wave at 0-dB. A high *Return Loss* (say -25 dB) equates to low SWR because the amount of reflected power in the system is

minimal compared to forward power. A smaller number (-9.5 dB) equates to higher SWR (~ 2:1) because the difference between forward and reflected power is less. *Reflection Coefficient* (**ρ)** expresses the voltage relationship between the reflected wave and the forward wave on a scale of 0 to 1.0. A *Reflection Coefficient* of 0.2 is approximately equal to 1.5:1.

To access and view measured data for *Return Loss* **(RL)** and *Reflection Coefficient* **(ρ)**:

[ ] Turn on the analyzer and allow it to boot to the basic system default mode (**R&X**).
[ ] Connect the DUT to the **Antenna** jack
[ ] Press **Mode** and **Gate** together until **Advanced** appears on-screen, then release.
[ ] Press **Mode** *once* to access *Return Loss & Reflection Coeff.*
[ ] Wait for the working screen.



[ ] Adjust the **Frequency** switches and **Tune** control to the desired test frequency (**MHz**).
[ ] Read numerical *Return Loss* (**RL**), (**SWR**), *Reflection Coefficient* (**ρ***)* on the display:
[ ] Read *Impedance* and *SWR* on the analog meters.

5.5 Distance To Fault: In **DTF** mode, you can measure the physical length of a random run of cable or find the distance to a fault in a transmission line. To do it, you'll first measures the *electrical distance* to the abnormality (or the cable end), then multiply it times *Velocity Factor* to get a physical distance in feet. At the far end of the cable, open and shorted terminations yield the best accuracy (resistive or reactive terminations can skew results or fail to test). You may also test balanced line using this method, but it requires a special procedure to keep the line in balance and isolated from ground (see below). Coax can be tested in any configuration.
Balanced Line: To avoid proximity errors, twin-lead, window line, ladder line, and open-wire feeders needs to be suspended in a straight line in the air and a few feet away from earth or other conductors. The analyzer must also be isolated from proximity to ground by running on internal battery power with only the feedline under test attached. One leg connects to the **Antenna jack** center pin and the other goes to the analyzer ground stud or connector flange.

To measure fault distance:
[ ] Connect the DUT to the **Antenna** jack
[ ] Enter **Advanced** Mode
[ ] Press Mode *twice* to access **Distance To Fault.** Wait for the working screen:

The top line shows **Frequency** and a blinking **"1st"** prompt. The lower line shows *Reactance*. To find electrical length, you'll find and enter two consecutive frequencies where (**X=0**).

[ ] Using the **VFO**, search for the *lowest frequency* you can find where the *Impedance* meter shows a sharp null and the display shows **X=0** (or as close to 0 as possible).

[ ] Press **Gate** to enter that frequency. The display will switch to the **2nd** prompt

3.8944 MHz **1st**	3.8944MHz **2nd**
DTF **X=0**	DTF X=0

[ ] Tune the **VFO** *higher* in frequency to find the next **X=0** null (or close as possible to 0).

11.519 MHz 2nd
DTF **X=2**

[ ] Press **Gate** to enter second frequency. Display will show:

Dist. to fault
64.0 ft x Vf

[ ] Multiply **DTF** x *Velocity Factor* of the cable (*Vf)* to get the *physical* distance in feet.
(64.0 x .66 = 42.24)

The cable length (or the distance to a "fault" in a longer cable) is 42.24 feet, or 42' 3".

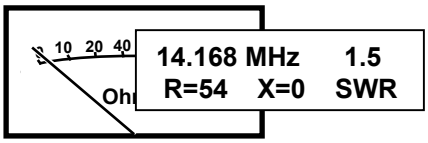
5.6 Resonance Mode: Resonance mode works exactly the same as **R&X** in the *Basic Menu*, except the analog *Impedance Meter* displays *Reactance* rather than *Impedance Magnitude*. This change makes it easier to spot nulls and pinpoint the frequencies where *Resonance occurs.* Resonance is defined as the frequency where *Capacitive Reactance* (**Xc**) and *Inductive Reactance* (**X_L**) cancel out and equal zero (**X=0**).

To access *Resonance Mode:*

[ ] Connect the DUT to the **Antenna** jack
[ ] Enter **Advanced** Mode
[ ] Press Mode *three times* to access **Resonance Mode** and wait for the working screen:

Resonance Mode	**14.150 MHz 1.5**
tune for X=0	**R=54 X=4 SWR**

[ ] Watching the *Impedance* meter, tune for a null (**X=0** or as close as possible).

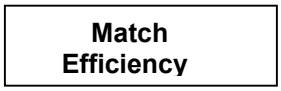


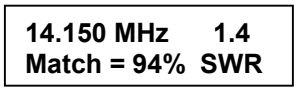
Accuracy Note: When measured thought feedline, *the **X=0** reading many not occur on the frequency where the antenna is actually resonant.* As with any reactance measurement, the analyzer *Calibration Plane* must be positioned close to the DUT (or to 0-degrees of phase rotation) as possible.

5.7 Match Efficiency: Also called *Percentage of Transmitted Power*, this measurement is directly related to *Percentage of Reflected Power*. By definition, the *Percentage of Transmitted Power* plus the *Percentage of Reflected Power* equals = 100% (see the SWR equivalency chart at 5.1). If the *Percentage of Reflected Power* measures 25%, then the *Percentage of Transmitted Power* will equal 75% (100% - 25% = 75%).

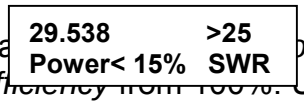
Important Accuracy Note: Note that this measurement *is very easy to misinterpret because it contains the word "Transmitted Power"* (implying "radiated power")*.* The *Percentage of Transmitted Power* simply represents the percentage of forward vs. reflected power present in the feedline at any given moment, and not the percentage of the transmitter's output power that ultimately performs work. Reflections occur at both ends of the transmission line, so the "real" power ultimately absorbed by the load after multiple bounces could be significantly more or less than the Match Efficiency value suggests!

To enter **Match Efficiency:**
[ ] Connect the DUT to the **Antenna** jack
[ ] Enter **Advanced** Mode
[ ] Press Mode *four times* to access **Match Efficiency** and wait for the working screen:





Note that if **SWR** exceeds the analyzer's 25:1 measurement limit, this message appears:



Percentage of Reflected Power: To ca*of Reflected Power* from *Match Efficiency*, simply subtract the *Match Efficiency* from 100%. Using the example above, % Reflected Power = (100% - 94%) = 4%.

6.0 Adjusting Simple Antennas

6.1 General: This chapter focuses on practical tips to help you get the most from your back-yard antennas using the MFJ-259C. To begin, here are some pointers to keep in mind when working with amateur radio antenna system:

1. Impedance and Calibration Plane: When measuring impedance and reactance, we've emphasized how important it is to "position" the analyzer's *Calibration Plane* close to the element feedpoint (or DUT). Alternatively, you may physically separate the calibration plane from the load by installing a precisely cut electrical half-wave of cable in between. Doing so rotates phase a full 360 degrees so there appears to be no phase shift (**= 0°**) or impedance transformation (**Z**) error. This strategy works well, but is a "single frequency" solution. Even a small excursion (more than ± 2° of phase shift) from the cable's "cut" frequency will skew impedance readings as the cable becomes non-resonant and begins to reintroduce its own

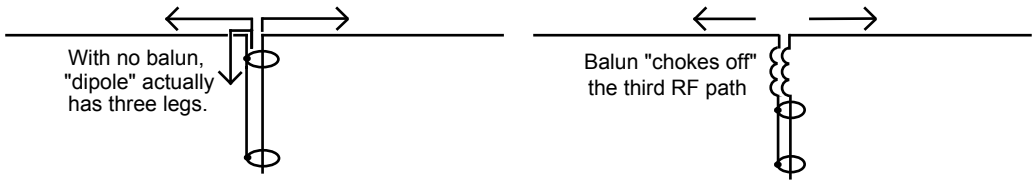
reactance into the system. Phase errors compound with multiple half-waves, so it's best to limit length to one or two phase rotations.

2. SWR, Resonance, and Impedance: Always use **SWR** rather than *Resonance* (**X=0**) or *Impedance magnitude* (**Z**) to optimize simple antennas. SWR is much easier to measure accurately because feedline length and calibration plane placement aren't critical. Also, if you cut the element based on *Resonance* alone (X=0), a significant *resistive mismatch* may still be present that shifts minimum SWR elsewhere. And, if you cut for Z=50 Ohms alone, you may get a large *reactive component* yielding the same outcome. SWR is always your best bet.

3. Tuning vs Matching: Unlike simple wire dipoles or verticals, many antennas have a built-in impedance matching networks (Delta, Gamma, Shunt, etc). These antennas may be adjusted for both resonance *and* impedance. Begin by setting up the prescribed element length for your target frequency using the manufacturer's instruction sheet, a model, formula, or X=0 measurement. Then, adjust the antenna's matching network for minimum SWR. In most cases, the two adjustments will interact, so be prepared to alternately touch them up. Again, minimum SWR at your target frequency should be the last word.

4. Feedline and SWR: If all is well, feedline length won't have much impact on SWR readings. You should be able to add or remove cable or measure SWR at any point along the way with little change. It's normal to see a small SWR drop when adding cable or an increase when removing it because of resistive loss. But, if you see big SWR changes when altering feedline length, repositioning the cable, or grounding the shield at any point, suspect a problem.

5. Radiating Feedlines: *Common-Mode RF Current* flowing along the outer surface of the coax shield is always be a prime suspect when you see erratic SWR changes. It happens when the feedline becomes part of the antenna element and radiates RF (hence the sensitivity to cable length, positioning, and grounding). With a radiating feed, it's virtually impossible to measure the antenna's actual resonant frequency or SWR because the load presented by the feedline alters these parameters unpredictably.



A Guanella current balun installed at the feedpoint offers the best protection against RF conducting down the outside of the cable. The balun functions as a choke to isolate the coax shield from the part of the antenna that's supposed to be radiating. It's also important to run coax away from the antenna at a 90-degree angle to prevent RF from coupling onto the line by induction. These two steps not only stabilize SWR, they reduce receiver noise, get rid of RF in the shack, and allow the antenna to radiate predictably.

6. Defective Cable: Erratic SWR readings will also occur if your coax isn't 50 ohms. Kinks, water ingress, oxidation, corrosion, bad connectors, improper construction, and even mislabeling by the manufacturer may be the cause. Check SWR with a dummy load installed

at the far end of the cable. If it is elevated or the *Impedance* (**Z**) fluctuates very much as you tune the analyzer's VFO, suspect defective cable.

7. Lossy Cable: Coax may exhibit excessive loss from contamination or may have too much normal attenuation for use at higher operating frequencies. To measure loss, unhook the cable and use the analyzer's *Coax Loss* mode to check it against the factory specifications.

6.2 The Coax-Fed 1/2-Wave Dipole:

Baluns (again): The 1/2-wave dipole is a balanced radiator and coaxial cable represents an unbalanced feed system, so it's especially important to install a balun at the feedpoint. Your balun could be a number of turns of coax wrapped into a coil several inches in diameter and taped to the feedpoint, or it could be a complicated affair with many interconnecting windings on a ferromagnetic core. The best choice is a simple 1:1 Guanella "current" balun wound on a toroid core made from material with the appropriate permeability (43-Mix preferred for most HF applications). If the feedline isn't isolated, it may load the element and impact a number of parameters -- including your calculations for the correct element length.

Tuning to Frequency: A dipole's minimum-SWR frequency is mainly determined by element length. If it's too long, minimum SWR will occur below the target frequency. If too short, it will occur above. The formula for length is shown below:

$$\text{Length in Feet} = \frac{468}{\text{Freq. in MHz}}$$

1.85 Mhz = 253'	7.15 MHz = 65' 5"	21.25 MHz = 22'
1.925 MHz = 243'	10.12 MHz = 46' 3"	24.93 MHz = 18' 9"
3.6 MHz = 130'	14.25 MHz - 32' 10"	28.5 MHz = 16' 5"
3.85 MHz = 121' 7"	18.11 MHz = 25' 10"	50.15 MHz = 9' 4"

Length is primary, but other factors may also enter in. "Fat" wire or larger tubing tends to lower the frequency below formula by introducing capacitive loading. Dipoles made with jacketed wire may resonate low because the velocity of propagation (Vp) is slowed by the insulation. Ground conductivity, soil moisture, proximity to other wires, nearby structures, and metal surfaces also have an impact. And, some specific types of dipoles (inverted "V", NVIS, OCFD, etc) may tune a little differently because of how they are configured.

Scaling: With so many variables, it's usually better to cut your antenna 5%-10% longer than formula, put it up, measure the SWR, and calculate a *Scaling Factor* to nail down the exact length you need at your specific location. To scale for length, follow this procedure:

[ ] Calculate element length, then multiply the result *x1.05* to make it 5% longer.
[ ] Built it, then measure and write down the *exact length* in feet. Call it $\mathbf{L_1}$.
[ ] Put the antenna up in the location where you intend to install it permanently.
[ ] Set the analyzer for SWR (**R&X**) and tune the **VFO** for the minimum SWR reading.
[ ] Write down the minimum SWR frequency as $\mathbf{F_R}$ (reference frequency).
[ ] Write down the target operating frequency as $\mathbf{F_T}$ (target frequency)
[ ] Calculate a *Scaling Factor* ($\mathbf{S_F}$) to determine the amount of change needed:
    If $\mathbf{F_R}$ is a lower frequency than $\mathbf{F_T}$, let $\mathbf{S_F} = \mathbf{F_T/F_R}$. (scaling factor <1.0).
    If $\mathbf{F_R}$ is a higher frequency than $\mathbf{F_T}$, let $\mathbf{S_F} = \mathbf{F_R/F_T}$ (scaling factor >1.0).

[ ] Calculate the new (target) antenna length (L_2) as follows: $L_2 = L_1 \times S_F$.

Example: Your 132-foot dipole has minimum SWR at 3.750 Mhz. You want it at 3.900 MHz. The element is presently too long, so: $S_F = F_T/F_R = 3.750/3.900 = 0.96$.
The new length will be: $L_2 = L_1 \times S_F = 132' \times .96 = 126.7'$.

Scaling eliminates time-consuming "cut-and-try", but it only works on full-size dipoles and verticals with no loading coils, matching networks, traps, stubs, capacitance hats, etc.

Dipole Height: Dipole resistance is mainly influenced by proximity to ground. Most dipoles match quite well through 50-Ohm coax at normal residential mounting heights (hence their popularity). By altering height, you may be able to improve your match. However, don't let SWR be your only consideration! If the change places too much stress on high tree branches or changes the angle of radiation unfavorably (local vs DX), why change? A small improvement in SWR will have little impact on your station's overall performance.

Radios, Impedance, and SWR: When antenna and feedline aren't precisely matched, we know the coax will act like a transformer and modify the value of the load appearing at your radio (same dynamic that applies to your analyzer's calibration plane). However, if you use good-quality 50-ohm cable and set your station up properly, most solid-state radios have no problem handling these impedance excursions as long as the SWR remains below 2:1. As Section 6.1 pointed out, your SWR shouldn't change even though the impedance may shift around because of phase rotation in the cable.

6.3 Verticals:

1/4-Wave Vertical: All 1/4-wave monopoles require a good ground system. If your radial system is poor, the "good earth" will swallow up a large portion of your signal as ground loss. In fact, you can often gauge the integrity of your radial field by measuring the antenna's driving resistance (the value of **R** when **X=0**). It should be low -- around 25-35 Ohms. If your 1/4-wave vertical shows a tidy 1:1 match through 50-Ohm cable, that's your cue to lay out more radial wire. Radials placed on the ground need not measure exactly 1/4-wave to be effective, but a minimum of 16 is recommended and *more is always better*. Antenna books cover radial systems extensively, although not all authors may agree on the best way to construct them.

A 1/4-wave vertical tunes the same way as a dipole -- lengthen to lower operating frequency and shorten to raise it. Monopole length can be scaled unless the element is loaded with a hat or a loading coil. Because the impedance is (or should be) quite low, most require matching at the feedpoint to make the transition up to 50 Ohms (shunt matching coil, L-network, auto-transformer, etc.). HF monopoles with a good radial system underneath are efficient, have a very low angle of radiation, and make excellent DX transmitting antennas.

Ground-Independent Verticals: These antennas don't require radial systems because they have a counterpoise of some sort built in. Most are configured as multiband OCFDs (off-center

fed dipoles) with the longer leg being the dominant vertical radiator. The counterpoise is often fanned out at the base as sloping radials or as a capacitive-hat structure. Ground-independent verticals are really "dipoles" oriented in the vertical plane, and they tend to work more efficiently when elevated well above ground. Mounted close to the soil, they tends to detune and radiate less efficiency because of ground losses. Most are multi-band arrays with the larger vertical radiator using resonant elements connected in parallel, traps installed in series, or a combination of both. Also, most utilize a built-in matching network and balun at the feedpoint to match into 50-Ohm coax. Tuning procedures may be somewhat complex and interactive for arrays with multiple bands, so its important to follow the manufacturer's procedure for tune up.

7.0 Special Measurement Procedures

7.1 Overview: There are a number of *specialized measurement procedures* you can follow to extend the versatility of your MFJ-259C. These include the following tasks:

- Measuring and cutting a transmission line stub to *Electrical Length*.
- Measuring the *Velocity Factor* (**Vf**) of an Unknown Cable.
- Finding the *Impedance* (**Z**) of an unknown feedline or Beverage antenna.
- Pre-adjusting an antenna tuner.
- Testing RF transformers and baluns for isolation.
- Analyzing RF chokes for *Self-resonance*.

7.2 Measuring and Cutting a Line or Stub to Length: To cut a matching stub or a resonant length of transmission line, use the analyzer's default *SWR/Impedance* function in the *Basic Menu* (**R&X**).

[ ] For **1/4λ** and odd multiples (1/4λ, 3/4λ, 5/4λ, etc), *terminate the cable with an **open***.
[ ] For **1/2λ** and even multiples (1λ, 1-1/2λ, 2λ), *terminate with a **short**.*
[ ] *Coaxial lines* may be piled or coiled on the floor -- no isolation from ground needed.
[ ] *Balanced lines* require isolation from ground. See the setup outlined in Chapter 5.5.

Next, determine your target frequency (F_T) and estimate cable length as follows:

[ ] Calculate **1λ** in **feet** = (**983.6 / Freq. MHz**), or **1λ** in **inches** = (**11803 /Freq. MHz**)
[ ] Multiply **1λ** by the **fractional length** you need (eg λ x .25 for 1/4λ, 1λ x .5 for 1/2λ, etc.)
[ ] Look up or measure your cable's ***Velocity Factor*** (**V_f**)
[ ] Convert the cable's ***Electrical Length*** to a ***Physical Length***: $L_{PH} = L_{EL} \times V_f$
[ ] Cut the cable ***20% longer*** than your calculated *Physical Length*: $L_{CUT} = 1.2\ L_{PH}$
[ ] Connect one end to the analyzer and terminate the other end as specified (**short** or **open**).
[ ] Tune the analyzer **VFO** to find the *frequency of the lowest Impedance null*.
[ ] Fine-tune, watching the *Reactance* (**X**) display. Adjust as close to X=0 as possible.

If calculations and the *Vf* accurate, your null should occur ~20% below the target frequency to reflect the added length. Next, calculate a scaling factor to determine *exact cut length*. You've initially cut the cable 20% "long and low", so your scaling factor will always be less than 1.0:

[ ] To find the *Scaling Factor* (**S_F**), divide the *null freq.* **F_1** by the *target freq.* **F_2**: (**$S_F = F_1/F_2$**)
[ ] Multiply the *Scaling Factor* (**S_F**) by the *present physical length* (**$S_F \times L_{cut}$**) for a final length.
[ ] Cut the stub and confirm the new reactance null (X=0) is on your target frequency.

7.3 Measure Velocity Factor (Vf) of a Unknown Cable: *Velocity of Propagation* (**Vp**) and *Velocity Factor* (**Vf**) are terms that express how fast RF propagates on a conductor relative to the speed of light. Although the two terms are often used interchangeably, *Velocity of Propagation* is usually given as a percentage (example: Vp = 66%) while *Vf* expresses the percentage as a multiplier for making frequency and length calculations (example: Vf = .66). To determine *Velocity Factor (Vf)* for a unknown transmission line:

[ ] Refer to **DTF** (Chapter 5.5) and find the *Electrical Length* of your cable in feet.
[ ] Follow the **DTF** procedure.

Your cable's *Electrical Length* will be the **DTF** result without a *Vf* calculated in to the resut (see below). Label your result **L_{EL}** (for *Electrical Length*).

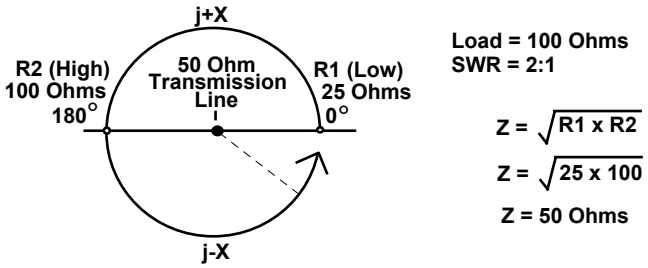
Dist. to fault
64.0 ft x Vf

[ ] Using a tape or rule, measure the *Physical Length* of your cable in feet. Label it **L_{PH}**.
[ ] Divide *Physical Length* by *Electrical Length* to find *Velocity Factor*: **$Vf = L_{PH} / L_{EL}$.**

Example: If the *Electrical Length* is 64 feet and the *Physical Length* is 42' 3" (42.25) feet, then the measured *Vf* of the cable calculates 0.66: (42.25 / 64 = .66).

7.4 Impedance of a Transmission Lines or Beverage Antenna: This procedure measures the *Impedance* of an *unknown transmission line* (or Beverage), from 7-650 Ohms. If needed, the range may be extended using a broadband transformer or a known resistance. Use the analyzer's *Basic Mode* (**R&X**) augmented by the *Impedance Magnitude* feature (**Z**) provided by the **Gate** key.

Methodology: Transmission lines have a "characteristic impedance" (50 Ohms, 70 Ohms, 300, 450 Ohms, etc). When a line is terminated by a load of the same impedance, no impedance transformation occurs between the near end and far end, regardless of electrical length. However, if we introduce a mismatch at one end, the impedance at the far end cycles above and below the cable's *characteristic impedance* with changing frequency.



Viewed on a Smith Chart, the transformed load impedance (R ±jX) literally traces a circle around the characteristic impedance of the transmission line with each 360-degrees rotation. The greater the mismatch, the larger the diameter of the circle. We can use this behavior in two different ways to determine the impedance of an unknown transmission line.

One way is to *intentionally introduce a resistive mismatch* at one end of the line and measure the amount of impedance transformation it causes at frequencies where X=0. As shown above, for each full rotation there will be two *Zero-Crossing Points* where X=0 and the load becomes purely resistive. One occurs below the line's characteristic impedance and the other above. Using the high and low resistive values (R1, R2), we can calculate the impedance of the line. Or, alternatively, we can connect a series of trial loads at the far end of the cable until we find a value where the impedance excursions are reduced to zero (the line's characteristic impedance).

When running these test, coax may be piled or coiled on the floor, but balanced lines must be isolated as described in Chapter 5.5. Connect Beverage antennas directly to the analyzer.

Intentional Mismatch Method: To ensure accuracy, use a non-inductive load and choose a value that holds the high and low impedance excursions well within the analyzer's accurate measurement range (7-650 Ohms).

[ ] Connect the cable to the analyzer and terminate the far end with the load you have chosen.
[ ] Tune **VFO** for the *lowest frequency* where *Impedance* and *Resistance* indicators both *dip*.
[ ] Fine tune to locate the point where **X=0** and **R** are both at their *minimum value*.
[ ] Press **Gate** to confirm θ = 0°. Write down the *Resistance* (**R**) reading as R1.
[ ] Tune up in frequency to find a distinct *Impedance peak*.
[ ] Fine tune to locate the point where **X=0** and *Resistance* (**R**) peaks at maximum value.
[ ] Press **Gate** to confirm θ = 0°. Write down this Resistance (**R**) reading as R2.
[ ] Multiply R1 x R2 and find the square root of the product.
[ ] The result is the characteristic impedance of your line.

Example: R1=36 ohms and R2 = 71 ohms, (36 x 71 = 2556), square root = 50.6 ohms.

If you wish to confirm the result, try other load values.

Load Substitution Method: At HF, use non-inductive fixed-value resistors, a physically small carbon potentiometer or trimpot, a (compact) decade box, or a broadband transformer of known accuracy (to extend range). Above HF, avoid any load that could introduce stray

inductance through lead length or internal structure. For best accuracy with a variable load, disconnect and check its value with a digital ohmmeter at the conclusion of the experiment. *However, never check load resistance with an ohmmeter with the analyzer connected -- the results will be inaccurate and the meter's DC voltage could damage the detector diodes!*

[ ] Connect the DUT cable to the analyzer and terminate the far end with your first trial load.
[ ] Tune the **VFO** up and down over a wide frequency span. Note the *Impedance changes*.
[ ] Try different terminations until the Impedance remains constant over the tuning range.
[ ] The resistance holding *Impedance* most constant is the line's characteristic impedance.

Important Warning: Never check the resistance of an adjustable load using an ohmmeter if the analyzer is connected at the opposite end of the line!

7.5 Pre-adjusting Antenna Tuners

Using the MFJ-259C to pre-adjust the impedance match through your station's tuner (ATU) avoids exposing the transmitter PA to high-SWR loads and eliminates needless over-the-air interference. The analyzer may be temporarily patched to the tuner's input using a short cable, but many operators prefer to install a manual RF switch to facilitate rapid changeover. If you choose to switch the analyzer, confirm:

- Your switch has more than 50 dB of port Isolation
- The wiper (or common) switch port is connected to the *Input Jack* of the tuner
- There's no possible way for the analyzer to become connected to a transmitter.

To pre-adjust the tuner:

[ ] Patch or switch in the analyzer.
[ ] Tune the **VFO** to your target frequency and leave it there
[ ] Select the default **R&X** mode in the *Basic* menu.
[ ] Adjust the tuner controls until *SWR* indicators show 1.0 (or as close to 1:1 as possible).
[ ] Turn off and disconnect the MFJ-259C
[ ] Reconnect the transmitter to the tuner.

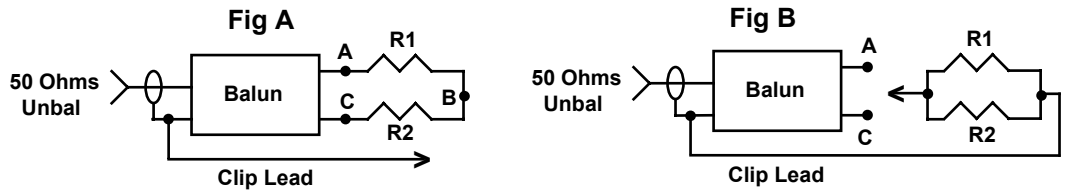
7.6 Testing RF Transformers: You can evaluate any RF transformer that has a termination port between 25 and 100 Ohms available on one of its windings. Use only non-inductive resistances for loads:

[ ] Connect the test port to the analyzer with a *very short* 50-ohm pigtail (<1° phase shift).
[ ] Terminate all other port(s) with loads of the specified impedance.
[ ] Set the analyzer to the default **R&X** function in the *Basic* menu.
[ ] Sweep the **VFO** across the transformer's intended operating range.

Use *SWR, Resistance* (**R**) *Reactance* (**X**) and *Impedance Magnitude* (**Z**) to evaluate the transformer's impedance and useable bandwidth. To measure efficiency, compare the source

voltage at the input port generated by the MFJ-259C to the load voltages at the other ports using standard power-level conversions.

7.7 Testing Baluns: To evaluate the performance of "current" and "voltage" style baluns, follow the outlined procedures referring to Figures A and B below:



[ ] Set the analyzer to the default **R&X** function in the *Basic* menu.
[ ] Set the **VFO** to the midpoint of the Balun's operating range
[ ] Connect the analyzer to the balun's 50-ohm unbalanced input.
[ ] Terminate the balanced side with equal-value load resistors as shown:

Use two equal-value non-inductive resistances. For a 4:1 balun with a 200-ohm secondary, configure a pair of 100-ohm resistors in series. For a 1:1 balun with a 50-Ohm secondary, connect 50-Ohm resistors in parallel to make a pair of 25-Ohm resistors, or if using standard values, connect 47 and 56-Ohm resistors in parallel to make up 25.5 Ohm loads. To evaluate your balun, refer to *Figure-A*:

[ ] Measure *SWR* while connecting the grounded clip lead to points A, B, and C.

Current Balun: A well-designed current balun will exhibit low SWR over its entire operating range with the clip lead installed at **A**, **B**, or **C**.

Voltage Balun: A well designed voltage balun will exhibit *low SWR* over its operating range with the clip lead installed at *position* **B**. However, it will show *poor SWR* with the clip lead installed at **A** or **C** (elevated readings should be the same). To further test the voltage balun, connect as shown in *Figure-B*. If operating properly, SWR will be remain low with the resistors connected from either output terminal to ground.

A well-designed current balun works best for maintaining current balance on a dipole under "real world" conditions where some asymmetry in loading may exist between the two legs. The current balun also has the highest power capability and lowest loss for given materials.

7.8 Analyzing RF chokes for Self-resonance: Large RF chokes often have frequencies where the distributed capacitance and inductance form a low impedance *series-resonance*. *Series resonance* occurs because the choke winding acts like a succession of back-to-back L-networks. This condition can lead to three problems:

- End-to-end Impedance of the choke becomes very low.

- Voltage at the center of the resonance becomes high, causing severe arcing.
- Current in the windings becomes very high, resulting in severe heating.

To test for self-resonance:

[ ] Install and test the choke in its normal operating location to incorporate stray capacitance.
[ ] Disconnect any choke leads leading to associated circuitry.
[ ] Connect the analyzer to both ends of the choke using a short 50-Ohm jumper.
[ ] Set the analyzer for its default **R&X** function in the *Basic* menu.
[ ] Tune the **VFO** to slowly sweep the choke's target operating range (specific band, etc).
[ ] Looking for impedance dips. These identify series-resonant frequencies.

When a low-impedance dip is detected, move a small insulated screwdriver blade along the choke windings to find a point where the series-resonate impedance changes suddenly. This jump identifies the location where the voltage peaks, and it's the spot where adding or subtracting even a tiny amount of capacitance will have the greatest effect. To shift the resonance off the critical frequency (or out of the band), try removing turns to reduce capacitance -- or add a capacitive stub. Note that even a small change in capacitance has a much more impact than making a small change in inductance because the L to C ratio is very high.

8.0 Technical Assistance

If you have any problem with your MFJ-259C, first check the appropriate section of this manual. If the manual does not reference your problem and the problem isn't solved by reading the manual, you may call *MFJ Technical Service* at **662-323-0549** or the *MFJ Factory* at **622-323-5869**. We can serve you best if you have your unit, manual, and all pertinent information about your difficulty handy so you can answer questions the technicians may ask.

You can also send questions by mail to MFJ Enterprises, Inc., 300 Industrial Park Road, Starkville, MS 39759; by FAX to 662-323-6551; or by e-mail to techinfo@mfjenterprises.com. Send a complete description of your problem, an explanation of exactly how you are using your unit, and a complete description of your station.

LIMITED 12 MONTH WARRANTY

MFJ Enterprises, Inc. warrants to the original owner of this product, if manufactured by MFJ Enterprises, Inc. and purchased from an authorized dealer or directly from MFJ Enterprises, Inc. to be free from defects in material and workmanship for a period of 12 months from date of purchase provided the following terms of this warranty are satisfied.

1. The purchaser must retain the dated proof-of-purchase (bill of sale, canceled check, credit card or money order receipt, etc.) describing the product to establish the validity of the warranty claim and submit the original or machine reproduction of such proof of purchase to MFJ Enterprises, Inc. at the time of warranty service. MFJ Enterprises, Inc. shall have the discretion to deny warranty without dated proof-of-purchase. Any evidence of alteration, erasure, or forgery shall be cause to void any and all warranty terms immediately.

2. MFJ Enterprises, Inc. agrees to repair or replace at MFJ's option without charge to the original owner any defective product under warrantee provided the product is returned postage prepaid to MFJ Enterprises, Inc. with a personal check, cashiers check, or money order for **$7.00** covering postage and handling.

3. This warranty is **NOT** void for owners who attempt to repair defective units. Technical consultation is available by calling the Service Department at 662-323-0549 or the MFJ Factory at 662-323-5869.

4. This warranty does not apply to kits sold by or manufactured by MFJ Enterprises, Inc.

5. Wired and tested PC board products are covered by this warranty provided **only the wired and tested PC board product is returned.** Wired and tested PC boards installed in the owner's cabinet or connected to

switches, jacks, or cables, etc. sent to MFJ Enterprises, Inc. will be returned at the owner's expense unrepaired.

6. Under no circumstances is MFJ Enterprises, Inc. liable for consequential damages to person or property by the use of any MFJ products.

7. **Out-of-Warranty Service:** MFJ Enterprises, Inc. will repair any out-of-warranty product provided the unit is shipped prepaid. All repaired units will be shipped COD to the owner. Repair charges will be added to the COD fee unless other arrangements are made.

8. This warranty is given in lieu of any other warranty expressed or implied.

9. MFJ Enterprises, Inc. reserves the right to make changes or improvements in design or manufacture without incurring any obligation to install such changes upon any of the products previously manufactured.

10. All MFJ products to be serviced in-warranty or out-of-warranty should be addressed to:

MFJ Enterprises, Inc.,
300 Industrial Park Road
Starkville, Mississippi 39759 USA

and must be accompanied by a letter describing the problem in detail along with a copy of your dated proof-of-purchase.

11. This warranty gives you specific rights, and you may also have other rights which vary from state to state.